



Neonatal encephalopathy; early MRI assessment

A Thesis submitted for partial fulfillment of M.D.
degree in Radiodiagnosis

By

Suzan Farouk Ibrahim

M.B.B.Ch, M. Sc Radiodiagnosis
Ain Shams University

Under Supervision of

Prof. Dr. Mervat Ibrahim El-Gohary

Professor of Radiodiagnosis
Faculty of Medicine Ain Shams University

Prof. Dr. Khaled Abou Alfotouh Ahmad

Professor of Radiodiagnosis
Faculty of Medicine, Ain Shams University

Dr. Ahmed Mohamed Abd Rabou

Lecturer of Radiodiagnosis
Faculty of Medicine Ain Shams University

**Faculty of Medicine
Ain Shams University**

2017



*First and foremost, I feel always indebted to **Allah**,
the Most Kind and Most Merciful.*

*I'd like to express my respectful thanks and
profound gratitude to **Prof. Dr. Mervat Ibrahim El
Gohary**, Professor of Radiodiagnosis, Faculty of
Medicine Ain Shams University, for giving me the honor
and great advantage of working under her supervision,
valuable teaching and the continuous education extended
to me beyond the limits of this thesis.*

*My sincere thanks and utmost appreciation are
humbly presented to **Prof. Dr .Khaled Abo AlFetouh**,
Professor of Radio-diagnosis, Faculty of Medicine, Ain
Shams University, for his tremendous assistance,
professional experience and allowing me to conduct my
thesis investigations in the MRI unit of El-Demerdash
hospital under his supervision and analysis applying the
knowledge to practice.*

*My deep thanks are humbly presented to **Dr. Ahmed Abo Rabou**, Lecturer of Radiodiagnosis, Faculty of Medicine, Ain Shams University, for his meticulous supervision and tremendous assistance. It has been a long trip with him in my career. I really appreciate his patience and support.*

DEDICATION

*To My Beloved Husband, **Dr. Bassem Ezzat Georgy**, Consultant of Radiodiagnosis, your love and support made me reach this day and for you I dedicate every success I achieve in my life.*

*To **My Beloved Mother**, because of you I'm here today, Wish you and **My Father** are proud of me*

*I am indebted to **My family** and **My friends** for their endless and continuous help and support.*



Suzan Farouk Ibrahim

ABSTRACT:

Many preterm and some full term newborns show different abnormal clinical signs during or soon after birth that may indicate the presence of encephalopathy which could be caused by hypoxic, metabolic or infectious etiologies. Determining the presence of insult, its underlying cause and its extent is very critical as it dramatically affect the management of such neonates.

Magnetic resonance (MR) imaging is the most sensitive technique for assessing the developing brain providing highly detailed images of brain structures without exposing infants to ionizing radiation or health risks; it is increasingly used in clinical practice as the main imaging method for detecting neonatal brain injury.

In neonates and young infants, the standard MRI protocol consist of T1 and T2-weighted images (WIs) as well as axial diffusion or diffusion tensor images. DWI sequences are very sensitive for detecting acute HIE, whereas gradient (GRE) sequences can detect the smallest amount of hemorrhage

KEY WORDS:

Neonate, HIE, PLIC, Metabolic, Infection.

CONTENTS

Subject	Page
Introduction and aim of work	1
Review of literature:	
A- Postnatal development of white matter	4
B- Pathology of hypoxic ischemic encephalopathy HIE	14
C- Ultrasound and MRI manifestations of encephalopathy	30
Patients and methods.	66
Results	71
Illustrative cases	81
discussion	97
Summary and conclusion	112
References	113
Arabic summary	120

LIST OF ABBREVIATIONS

AA: Amino Acids

ADC: Apparent diffusion coefficient

AR: Autosomal Recessive

BP: Blood Pressure

CBF: Cerebral blood flow

Cho: Choline

CMV: Cytomegalovirus

CNS: Central Nervous System

Cr: Creatine

CSO: Centrum Semiovale

DTI: Diffusion Tensor Imaging

DWI: Diffusion weighted image

Fig: Figure

GA: Gestational Age.

GE: Gradient echo

Glx: Glutamine + Glutamate

GM: Germinal Matrix

GMH: Germinal Matrix Hemorrhage

GRE: Gradient Echo

HIE: Hypoxic Ischemic Encephalopathy

IR: Inversion Recovery

IUGR: Intra uterine growth retardation
IVH: Intra-ventricular Hemorrhage.
MR: Magnetic Resonance
MRA: Magnetic resonance angiography
MRI: Magnetic resonance imaging
MRS: Magnetic Resonance Spectroscopy
MSU: Maple Syrup Urine disease
NAA: N acetyl aspartate
NE: Neonatal Encephalopathy
NICU: Neonatal Intensive Care Unit
PCI: Parasagittal Cerebral Injury
PLIC: Posterior Limb of Internal Capsule
PPV: positive-predictive value
PUK: Phenylketonuria
PVL: Periventricular Leukomalacia
SE: Spin echo
SNN: Selective Neuronal Necrosis
SNR: Signal to noise ratio
TCUS: Trans Cranial Ultrasound
US: ultrasound
WI: Weighted image

LIST OF FIGURES

Fig.N o.	title	Pag.N o.
1.	MR images of the neonatal brain	5.
2.	Multilayered appearance of the cerebral hemisphere	6.
3.	Thirty weeks neonate brain MRI	7.
4.	Preterm newborn (30 weeks GA): T1-WIs. Myelination	8.
5.	Preterm newborn (30 weeks GA): T2-WIs. Myelination	8.
6.	Term newborn brain MRI T1WIs: myelination	9.
7.	MRI brain Newborn & 3 years old T1 & T2 WIs.	10.
8.	MRI brain One year old T1-WI	11.
9.	MR- DWI in a healthy neonate	12.
10.	DTI & Tractography. Major white matter fiber tracts	12.
11.	MR S in the white matter on neonate	13.
12.	TCUS. Loss of normal architecture	30.
13.	TCUS. Loss of normal grey–white matter differentiation	31.
14.	TCUS. severe hypoxic-ischemic injury	31.
15.	TCUS. Intra-ventricular hemorrhage	32.
16.	CT scan in full-term with severe, total hypoxia	33.
17.	MRI. Brain swelling	38.
18.	MRI attenuation of bright strip in the internal capsule	40.

19.	MRI brain. increased SI in the thalami and in putamen	41.
20.	MRI brain. Severe lesions of thalamus and basal ganglia	41.
21.	MRI brain. Brain stem lesions in term infants	44.
22.	MRI brain. Highlighting	45.
23.	MRI brain. Loss of gray/white matter differentiation.	46.
24.	MRI brain. Loss of G/W matter differentiation at 2 weeks	46.
25.	MRI brain. Dentate nuclei injury	47.
26.	MRI brain. Preterm infant. PVL	49.
27.	MRI brain. Cystic encephalomalacia	50.
28.	MRI brain. End-stage or chronic PVL in a preterm	51.
29.	MRI brain. Deep gray matter injury in a preterm infant	51.
30.	MRI brain. GMH & IVH in preterm	53.
31.	MRI brain. Term infant. Choroid plexus hemorrhage	53.
32.	MRI brain. Phenyl ketonuria	54.
33.	MRI & MRS brain. Ornithine transcarbamylase deficiency	55.
34.	MRS brain. Nonketotic hyperglycinemia	56.
35.	MRI & MRS brain. Maple syrup urine disease	57.
36.	MRI brain. Methylmalonic acidemia	58.
37.	MRI brain. Glutaric aciduria type I	59.
38.	MRI brain. Glutaric aciduria type II	59.
39.	CT & MRI brain. Congenital CMV infection	61.
40.	MRI brain. Neonatal herpes simplex encephalitis	62.

41.	MRI brain. Neonatal herpes simplex encephalitis 1 month	63.
42.	CT. Congenital rubella	63.
43.	MRI. Congenital rubella	64.
44.	CT brain. Congenital toxoplasmosis	65.
45.	MRI brain. Congenital toxoplasmosis	65.
46.	Bar chart. the frequency of the signs in studied pre-terms	73.
47.	Pie chart showing the frequency of degree of hypoxia.	74.
48.	Bar chart. the frequency of the signs in studied full-terms	76.
49.	Bar chart . frequency of enceph causes in full term neonates	77.
50.	Bar chart. frequency of signs full-terms with HIE.	79.
Case 1.a.d	MRI. HIE	81.
Case 2.a.d	MRI. HIE	83.
Case 3.a.f	MRI. MSU	85.
Case 4.a.d	MRI. HIE	87.
Case 5.a.d	MRI. HIE	89.
Case 6.a.f	MRI. Hypoglycemia	91.
Case 7.a.d	MRI PVL HIE	93.
Case 8.a.d	MRI. HIE	95.

LIST OF THE TABLES

NO.	table	Page.No.
1.	Characteristics of the study population	71.
2.	Relevant clinical data in preterm	71.
3.	Relevant clinical data in full-term neonates	72.
4.	signs in pre-terms	73.
5.	signs in full term	75.
6.	Major 4 diagnostic groups	77.
7.	Frequency of signs of HIE	78.
8.	Detailed table for the signs of full term neonates with abnormal MRI.	80. Append

INTRODUCTION

INTRODUCTION

Neonatal encephalopathy is a clinically defined syndrome of disturbed neurologic function in the earliest days of life, manifested by a subnormal level of consciousness or seizures, and often accompanied by difficulty with initiating and maintaining respiration and depression of tone and reflexes. (*D’Alton et al., 2014*)

Neonatal encephalopathy may result from hypoxic-ischemic injury (by far the most common cause), infectious diseases, metabolic disorders, trauma, and congenital disorders. (*Shroff et al., 2010*). It accounts for 15-28% of children with cerebral palsy. (*Chao, 2006*)

We use the term hypoxic-ischemic injury to designate any brain impairment caused by insufficient oxygenation and blood flow. This term should not be confused with hypoxic-ischemic encephalopathy (HIE), a condition that is diagnosed on the basis of specific clinical findings of profound acidosis, a poor Apgar score (0–3) at birth, seizure, coma, hypotonia, and multi-organ dysfunction. (*Shroff et al., 2010*)

HIE clinically presents within a few hours of birth with encephalopathy and can affect preterm as well as term infants. Clinical features such as history of peri-partum asphyxia, neonatal resuscitation, seizures and abnormal neurological status are indicative of HIE and require further assessment with imaging. Late clinical findings can vary from mild neurological impairment to severe neurological deficits, seizures and developmental delay. Imaging findings depend on severity of ischemic insult, maturity

of the neonatal brain, and time elapsed between the onset of injury and the imaging effort (*Badve et al., 2012*)

Accurate prediction of neurodevelopmental outcome in neonatal encephalopathy (NE) is important for clinical management and to evaluate neuro-protective therapies. (*Thayyil et al., 2010*)

It is crucial to consider the clinical history when interpreting MR studies of encephalopathic neonates: The gestational age at birth is predictive of the pattern of hypoxic-ischemic injury, with the pattern in preterm infants (those with a gestational age of less than 36 weeks) differing from that in full-term neonates (those with a gestational age of 36 weeks or more). (*Shroff et al., 2010*)

Cranial ultrasonography and computed tomography lack sensitivity for the evaluation of the nature and extent of brain injury in the term encephalopathic infant. (*D'Alton et al., 2014*)

Magnetic resonance (MR) imaging is the most sensitive technique for depicting the developing brain. Because it can provide highly detailed images of brain structures without exposing infants to ionizing radiation and associated health risks, it is increasingly used in clinical practice as the main imaging method for detecting neonatal brain injury. (*Shroff et al., 2010*)

Most neonatal MR studies are performed by using 1.5-T systems, although the availability of 3.0-T systems (with inherently higher signal to noise ratio SNR and magnetic susceptibility) is increasing. (*Shroff et al., 2010*)

In neonates and young infants, the standard MRI protocol consists of T1 and T2-weighted images (WIs) as well as axial diffusion or diffusion tensor images. (*Girard et al., 2012*)

DWI sequences are very sensitive for detecting acute HIE, whereas gradient (GRE) sequences can detect the smallest amount of hemorrhage. (*Badve et al., 2012*)

The use of dedicated MR-compatible incubators with built-in coils can save considerable time in transport and improve patient safety. (*Shroff et al., 2010*)

AIM OF THE STUDY:

The aim of the study is to assess the different MR patterns seen in neonatal encephalopathy.

.